

THE BIOLOGY AND CONTROL OF THE DARKBODIED PSYLLIDS  
AT MANHATTAN, KANSAS

by

RICHARD SPERRY TAYLOR

B. S., Michigan State College, 1950

---

A THESIS

submitted in partial fulfillment of the  
requirements for the degree

MASTER OF SCIENCE

Department of Entomology

KANSAS STATE COLLEGE  
OF AGRICULTURE AND APPLIED SCIENCE

1952

Spec. Coll.  
LD  
2668  
.T4  
1952  
T3  
C.2

11

## TABLE OF CONTENTS

|                                                                                                |    |
|------------------------------------------------------------------------------------------------|----|
| INTRODUCTION AND LITERATURE REVIEW .....                                                       | 1  |
| Key to the Species of <u>Pachypsvilla</u> .....                                                | 2  |
| Notes on the Habits of the Species of <u>Pachypsvilla</u><br>with a Review of Literature ..... | 3  |
| <u>Pachypsvilla venusta</u> .....                                                              | 3  |
| <u>Pachypsvilla celtidis-marra</u> .....                                                       | 4  |
| <u>Pachypsvilla celtidis-vesicula</u> .....                                                    | 5  |
| <u>Pachypsvilla celtidis-germa</u> .....                                                       | 5  |
| <u>Pachypsvilla celtidis-inteneris</u> .....                                                   | 6  |
| <u>Pachypsvilla pallida</u> .....                                                              | 6  |
| <u>Pachypsvilla dubia</u> .....                                                                | 7  |
| Control Measures .....                                                                         | 7  |
| METHODS AND MATERIALS .....                                                                    | 8  |
| Field Observations .....                                                                       | 8  |
| Rearing of Parasites .....                                                                     | 8  |
| Insecticidal Spray Tests .....                                                                 | 9  |
| EXPERIMENTAL RESULTS .....                                                                     | 10 |
| Local Distribution .....                                                                       | 10 |
| Life Histories .....                                                                           | 12 |
| Natural Control by Parasitic Wasps .....                                                       | 16 |
| Insecticide Spray Tests .....                                                                  | 18 |
| DISCUSSION OF RESULTS .....                                                                    | 20 |
| SUMMARY .....                                                                                  | 22 |
| ACKNOWLEDGEMENT .....                                                                          | 37 |
| LITERATURE CITED .....                                                                         | 38 |

## INTRODUCTION AND LITERATURE REVIEW

The insects of the genus Pachypsylla (Psyllidae:Homoptera), commonly known as hackberry psyllids, are all gall makers on the hackberry tree (Celtis), and are restricted in range, as is the hackberry, to the continent of North America. Tuthill's monograph on the family (1943), which contains the most up-to-date review of the genus, lists seven species of Pachypsylla in the United States: P. venusta (Osten-Sacken), P. celtidis-mamma (Fletcher), P. celtidis-vesicula Crawford, P. celtidis-gemma Riley, P. celtidis-intereris Mally, P. pallida Patch, and P. dubia Patch. Since Tuthill's work was published, Caldwell (1944) described and named P. tropicala on the basis of a single male specimen collected in Tepoztlan, Morelos, Mexico. Walton (1944), in his study of P. celtidis-gemma, indicated that the insect called P. cucurbita by Packard (1890) and subsequently considered to be identical with P. celtidis-mamma by other workers was a distinct species on the basis of its chromosome count.

Like many of the gall-making Hymenoptera, each species of Pachypsylla makes a specific kind of gall. In fact, many of the older workers described species of the insect on the basis of the gall alone and ignored the morphological characters of the insects themselves, with the result that there is considerable confusion concerning the synonymy and their varietal forms. While much more work is required to clarify the taxonomy of the genus it is sufficient for the purpose of this thesis to use

the nomenclature given by Tuthill.

The hackberry psyllids whose habits are known may be grouped into two categories: (A) the leaf gall makers, which form galls on some part of the leaf blade or petiole; and (B) the woody gall makers, which form galls on any part of the tree other than the leaf, these galls being of harder texture than the leaf galls. In the following key which is quoted from Tuthill, these divisions are indicated and the common names which are considered to be most descriptive of the insect's gall have been added.

Key to the Species of Pachypsylla

A. Leaf gall makers:

1. Head and thoracic dorsum with short stiff pubescence, not shining; marginal cells of forewing very elongate; forewings not rugose.....2
  - Head and thorax appearing glabrous, shining (often with sparse, minute pubescence); marginal cells less elongate, broad; forewings more or less rugose.....4
2. Large species (5.5-6 mm.)..... venusta
  - petiole gall psyllid
  - Smaller species. (4 mm. or less).....3
3. Length to tip of folded wings 3 to 4 mm...celtidis-mamma
  - nipple gall psyllid
  - Length to tip of folded wings 2.5 mm. or less.....
    - celtidis-vesicula
    - blister gall psyllid

## B. Woody gall makers:

4. Forewings uniformly brown.....celtidis-gerana  
bud gall psyllid  
Forewings maculate.....5
5. Branches of media sinuate.....celtidis-inteneris  
twig gall psyllid  
Branches of media not sinuate.....6
6. Forewings with large maculae (sometimes finely mottled  
also).....pallida

## C. Gall undescribed:

Forewings finely mottled apically.....dubia

The names "blister gall psyllid" and "twig gall psyllid" are, so far as is known, original; the others have been used by other authors.

The literature on the biology of the hackberry psyllids is scattered and incomplete; no single work contains the life-histories of more than one or two species in any detail. Therefore the following summary of the literature and known habits is arranged by species.

Notes on the Habits of the Species of Pachypsylla,  
with a Review of Literature.

Pachypsylla venusta. The galls made by this insect are polythalamous and located on the leaf petiole. A difference of opinion exists as to whether the adults emerge in the fall or in the spring. Tuthill (1943) wrote that they overwintered in the gall and emerged in the spring, but Wells stated that they emerged

in the fall and hibernated as adults on the bark.

In Idaho, Jensen (1946) reared three genera of Chalcidoid parasites from a group of petiole galls and nipple galls kept indoors during the winter. He listed Callinome sp., Eurytoma sp., and Psyllaephagus sp. near pachyosyllae but he did not know which parasites came from which galls.

An interesting phenomenon was observed by Knowlton (1933) in Utah, where he found adults of Paratriozoa cockerelli overwintering in a petiole gall which had been vacated by the Pachyosylla adults. He also found a parasite of the genus Amblymerus in a venusta gall.

This species has been recorded from Iowa, Kansas, Colorado, Texas, New Mexico, Ohio, Mississippi, Tennessee, North Carolina, New Jersey, Idaho, Utah, New York and Connecticut.

Pachyosylla celtidis-mamma. This species overwinters in the adult stage in the crevices of bark (no specific tree has been mentioned); in the spring, the adults mate and lay eggs as the leaves appear. The nymphs feed on the lower side of the leaves and create a nipple-shaped gall. The adults emerge in September (Tuthill, 1943). Mally (1894) described the egg, nymph, and adult, and Stough (1910) made a study of the comparative morphology.

The nipple gall psyllid has been recorded throughout most of the eastern and midwestern parts of the country.



Pachypsylla celtidis-vesicula. This insect follows a life-cycle similar to that of the preceding species. According to Caldwell (1938), the eggs are laid on the under side of the leaves. They begin to hatch in twelve days and the nymphs crawl to the upper side of the leaves to begin feeding. Eight to twelve days later, they are enclosed in a blister-like gall. The nymphal period is 136 days, after which the adults emerge and go almost directly into hibernation.

In severe infestations, P. celtidis-vesicula and P. celtidis-mamma often make themselves conspicuous by accumulating in large numbers on window screens after emerging in the fall (Tuthill, 1943).

Collection records from the literature list this species from Iowa, Kansas, Nebraska, Oklahoma, Arizona, Louisiana, Ohio, New York, New Jersey, and Connecticut.

Pachypsylla celtidis-gemma. The bud gall psyllid has been more thoroughly studied than any other species of this genus. Weiss (1921) gave an account of the life-history and Walton (1944) described the instars and studied histologically the effect of the nymphs upon the young buds. The latter author found that little damage was done to the tree by this species since enough buds escaped injury to keep the tree healthy; however, older trees attacked heavily appeared unsightly because of the galls.

P. celtidis-gemma is the only species of this genus which has been reported to feed on plants other than hackberry.

In 1895 Elingland mentioned an infestation of bud galls made by P. celtidis-gemma on mulberry. The eggs were laid in May and June on the twigs. As a control, he suggested pruning out the infested twigs in the fall and burning them. Crawford, in his monograph on the Psyllidae (1914), included the following locality and host record in his discussion of this species: "Natchitoches, Louisiana (Cushman, and Pierce), on Crataegus, March 28, 1907". The references by Cushman and Pierce have not been located.

Two species of parasites have been found to infest the bud gall psyllid. Waterston (1925) described Psyllaerphagus pachy-psyllae in Maryland; Walton (1944) found that in New York City, 31.6 percent of the nymphs were destroyed by this parasite. Another wasp affecting this species is Callomome scalaris, listed by Huber in 1927.

Bud gall psyllids have been collected in most states from Kansas to the Atlantic Coast.

Pachypsylla celtidis-inteneris. Little has been mentioned about this insect, probably because the galls, which are located under the bark of twigs, usually near the bases of buds (Tuthill, 1943; Caldwell, 1938), are very inconspicuous. This species has been recorded from Iowa, Illinois, and Ohio.

Pachypsylla pallida. Tuthill described the galls of this species as being on the twigs and appearing pubescent, possibly because of a fungus growth. Nothing more is known concerning its biology. It has been found in Arizona and New Mexico.



Pachynotylla dubia. This species was recorded from Utah by Klyver (1932). Nothing is known of its habits.

**Control Measures.** The only chemical control measures prescribed for hackberry psyllid infestations are kerosene emulsion (Kotinsky, 1921), and a nicotine-molasses spray (Felt and Bromley, 1930).

The lack of interest in control measures for members of this genus may possibly be explained by the facts that they cause no great economic loss, and their biology, a knowledge of which is essential to the success of a spray program, has not been intensively studied.

That more attention should be given to this may be deduced from the importance attached in recent years to the use of shade trees for street plantings and windbreaks. This is especially true in the middle-west, a region noted for its dearth of wooded areas. And it is in this area that the hackberry reaches its greatest value because of its adaptability to many soil types and its resistance to drought (U. S. D. A., 1926; U. S. Forest Service, 1935). Since severe local infestations of hackberry psyllids often disfigure the trees to the extent that their value as ornamentals is diminished, it follows that a practical control would make the trees more acceptable for plantings in municipalities and on farms.

Therefore it is the purpose of this thesis to present a survey of the activities of all the species of Pachynotylla occurring in Manhattan, Kansas, and to determine the practicability of a chemical control.

## METHODS AND MATERIALS

### Field Observations

During the autumn of 1950 and spring of 1951, thirty-five hackberry trees in the vicinity of Kansas State College were examined periodically for the presence of psyllids. A separate series of records was kept for each tree so that variations in the life-histories of the psyllids from tree to tree would become apparent if they existed. Each time the trees were examined, the following facts were recorded:

1. Size of leaf buds and young leaves in the spring.
2. Species of psyllids present on the tree.
3. Whether adults present were feeding, copulating, or laying eggs.
4. Presence and location of eggs, nymphs, and galls on the tree.

### Rearing of Parasites

Twigs on which galls of P. celtidis-gemma and P. celtidis-inteneris had formed were pruned from trees during January and February of 1951 and confined in vials at room temperature for the collection of adult parasites of the psyllids. A second group of galls was dissected with a needle to determine the number of psyllid nymphs which had been parasitized, and incidentally to find the number of cells per gall. Since the wasp larvae and pupae found in the second group of galls were not identified to species, the percentage of parasitism by each

species of parasite was not determined.

### Insecticidal Spray Tests

The spray experiments were timed specifically to control the blister gall psyllid, *P. celtidis-vesicula*, since this was the commonest species during 1950 and was responsible for most of the disfigurement of the trees in Manhattan. Therefore the effects of the sprays would be more apparent than in the case of a less prevalent species.

Since the intensity of infestations by this species was extremely variable from tree to tree, it was necessary to use the same tree for both a spray test and a check. On each tree used in the tests, a single lower branch was treated and tagged for identification and the rest of the tree was considered to be the check. All the trees selected were known to have been infested by *P. celtidis-vesicula* during 1950.

The three toxicants used were "Gamtex" wettable powder (10 percent gamma isomer of benzene hexachloride), "EPN-300" wettable powder, and a combination of "Black Leaf 40" (40 percent nicotine sulfate) and "Superla" summer oil. The "Gamtex" was used at the rate of 9.1 grams per gallon of water; the "EPN-300" at 4.56 grams per gallon; and the nicotine-oil at the rate of one teaspoonful of "Black Leaf 40" and two teaspoonfuls of oil per gallon. These concentrations were the ones recommended by the manufacturers for shade trees.

Each spray was applied to two different trees, making a total of six trees treated, during the evening of May 6. The

weather at the time of application was clear and mild, with no wind. The sprays were applied to the point of runoff with a three-gallon compressed air hand sprayer.

Two months after the spray applications, a count was made of the blister galls on the sprayed and unsprayed branches of the same tree. An accurate count was difficult to obtain because the galls were irregularly distributed from one leaf to another; some leaves bore up to one hundred galls while others nearby were entirely free of them. Small twigs on each branch were selected at random and the galls were counted on every leaf of the chosen twigs in an attempt to avoid inaccuracy by examining a disproportionate number of heavily infested leaves. This method was based on the assumption that on a large number of twigs, the ratio of heavily infested leaves to leaves free of galls was relatively stable.

## EXPERIMENTAL RESULTS

### Local Distribution

Examinations of thirty-five hackberry trees in Manhattan showed marked differences in the distribution of each species of Pachypsylla. While P. celtidis-vesicula, the blister gall psyllid, was the commonest and most evenly distributed species, this as well as others showed local variation in the intensity of the infestation. On twenty-four of the trees, the blister gall psyllid was predominant, every leaf bearing three or four to over a hundred galls. On the other hand, very few nipple

galls were found on these trees, while on another tree, almost every leaf bore several nipple galls as well as blister galls.

Wherever galls of P. celtidis-gemma, the bud gall psyllid, and P. celtidis-inteneris, the twig gall psyllid, occurred they were about equally common. On the twenty-five trees mentioned above, both of these species occurred sparsely; approximately five per cent of the buds were infested. On ten other trees almost all of the buds were infested by P. celtidis-gemma and the twigs had a lumpy appearance due to the large number of twig galls, but there were very few blister galls and nipple galls.

The petiole galls of P. venusta (Plate I) were rare on all of the trees examined.

This localization is difficult to explain on the basis of any observations made in the present study. Little is known about the flying ability of the psyllids, and it is not known where most of them hibernate. When adult psyllids were disturbed while they were feeding, they jumped powerfully away and then flew back. They were slow fliers and did not give the impression of being able to fly great distances. They have been found on window screens about 150 feet away from the nearest hackberry tree in such numbers that it is most probable that they flew there deliberately rather than being blown accidentally. It should be noted, however, that the most widespread species, P. celtidis-vesicula, was the one which could most easily be spread by wind during the fall. The psyllids making woody galls, on the other hand, have little time in which to disperse, since the trees are in full leaf at the time they emerge from the galls, and they lay their eggs very shortly thereafter.

## Life Histories

During the last half of October, 1950, before the hackberry leaves had fallen, the nymphs of P. celtidis-vesicula and P. celtidis-mamma emerged from their leaf galls through holes cut by rotating their abdomens, at the end of which are rings of short, stiff spines. They transformed into adults immediately after emergence. The adults were at first pure white, but became brown in about half an hour. In November they collected in large numbers on window screens and the bark of hackberry trees, but by early winter they dispersed to the extent that they were almost impossible to find. While most authors have stated that the adults overwinter on the bark, no good evidence of this could be found in Manhattan. Examinations of the leaves beneath the trees yielded a few psyllids but not enough to account for the large numbers seen earlier in the fall. Possible reasons for this may be their dispersal by flight or wind, or a high mortality rate during the winter.

It was not possible to determine whether adults of P. vcn-usta emerged in the fall or spring because no specimens were found at either time and no galls containing living nymphs were obtained in the fall. However, some indirect evidence was gathered from an examination of some petiole galls picked from a tree in April, before any adult psyllids were present on the trees. Most of the cells of these galls had been vacated by the adults. The cells which were still closed contained dead nymphs or living larvae of Hymenopterous parasites. One gall contained



a mass of eggs from a Geometrid moth and some fragments of a spider's body, apparently indicating that the gall psyllids had emerged the previous fall and the gall was being used as a hibernating place by other creatures. The label dates on some specimens of P. venusta in the Kansas State College collection support this conclusion. Some of the specimens were caught in Manhattan in November, 1946. Others were collected in October of an unspecified year.

The first psyllids to appear in the spring were P. celtidis-vesicula and P. celtidis-mamma, which had overwintered as adults. The time at which they were first seen was closely correlated with the time at which the hackberry trees began to leaf out. Considerable variation was evident in the time of spring at which the first leaf buds opened. The first swelling buds were seen on April 16, 1951; the last ones on May 30, on a single branch of a tree which otherwise was in full leaf. In both cases, adult blister gall psyllids were feeding and copulating on the newly opened buds and first leaves. Most of the trees began to leaf out in the last half of April and first week of May, and it was during that period that the most leaf gall making psyllids were seen. Throughout the budding and leafing period the adults fed and laid eggs almost entirely on the youngest leaves. As the leaves expanded and became less pubescent, the adults disappeared. It has not been established whether they die then or migrate to other buds. Within two or three days after the adults appeared they copulated and laid eggs on the under sides of the new leaves.

During copulation the adults were side-by-side on a twig or leaf, and facing in the same direction. The male attached itself to the female by extending its very flexible abdomen under its wings and curving it around to meet the end of the female's genitalia. The eggs (Plate II) were football-shaped, about twice as long as broad, smooth, glistening white, and were laid singly anywhere on the leaf surface. They hatched in eight to twelve days and the nymphs crawled to the upper sides of the leaves (Plate III) where they began to feed.

About a week after feeding started, the nymphs had sunk into a slight depression. In another three or four days the surface of the leaf had grown completely over the nymph, which showed no change in size up to the time it was enclosed in the gall. At first the gall was a barely visible nodule less than half a millimeter wide, and the same color as the rest of the leaf. It was more easily seen on the under side of the leaf than on the upper side even though the nymph had sunk in from the upper side, because the leaf tissue above the nymph had not yet thickened. About a month later, the gall was a millimeter and a half wide, convex on both sides of the leaf, and conspicuous because it was yellowish-green to yellow and contrasted with the normal dark green of the rest of the leaf. In the fall, when the leaves were turning yellow prior to falling, the galls turned brown and retained their conspicuous appearance.

P. celtidis-marina followed much the same life cycle as P. celtidis-vesicula. Since the former species was generally

less common than the latter, there did not seem to be any particular time during which it was most abundant. Instead, the adults were present on the buds and leaves in about the same concentration throughout most of the leaf-forming period.

The nymphs of this and the preceding species are pale yellowish-green, with red eyes, and a broadly oval, dorso-ventrally flattened body. When they were removed from their galls they crawled actively.

The nymphs of P. celtidis-mamma fed on the lower sides of the leaves and produced a nipple-shaped gall (Plate IV) which was light green with a whitish bloom. When young, the galls were sparsely pubescent; later they became glabrous. The upper surface was deeply concave. Occasionally the part of the leaf around the base of the gall was yellow.

The first adult wood gall psyllids, P. celtidis-gemma and P. celtidis-inteneris, were not found in any abundance until about a month after the first blister gall psyllids. At that time, the last instar nymphs, which had overwintered, emerged from the galls in the same way as the nymphs of the leaf gall makers did, and moulted to become adults on the twigs and young leaves. A single bud gall psyllid was collected on April 20, but no more were seen until May 17, when both species were present in large numbers on a tree which, during the winter, had a misshapen appearance due to the profusion of bud and bark galls (Plates V and VI).

Eggs laid by these species were first seen on May 20. They were white and similar in appearance to those of P. celt-

idis-vesicula; they were deposited singly or in groups of two to six in the angles formed by the branching of the veins on the under sides of the leaves, and were concealed so well by the hairs projecting from the veins that they were almost invisible except on very close inspection. By contrast, the eggs of P. celtidis-vesicula were scattered in full view over the entire young leaf so that the leaf had a speckled appearance.

#### Natural Control by Parasitic Wasps

Nymphs of P. celtidis-gemma in Manhattan, Kansas, are parasitized by two species of wasps, Psyllaephagus pachypsyllae (How.) and Torymus scalaris (Huber). Together, these wasps infested 18.4 per cent of the nymphs in 365 gall cells opened. Although this is appreciably less than Walton's finding of 31.6 percent by Psyllaephagus pachypsyllae alone in New York City, it still shows that these parasites contribute substantially to the natural control of the bud gall psyllid.

The dissection of galls for the study of parasites also revealed that the relative abundance of galls of any given number of cells was almost the same as that found by Walton. The only difference is that Walton's figures show a wider range in the size of the galls. Table 1 shows the comparison between his data and the data based on the dissection of 113 galls in Manhattan.

Table 1. Incidence of various sizes of bud galls.

| Number of cells<br>per gall | Per cent of<br>incidence in<br>New York City<br>(Walton) | Per cent of<br>incidence in<br>Manhattan, Kansas |
|-----------------------------|----------------------------------------------------------|--------------------------------------------------|
| 1                           | 10.0 percent                                             | 16.8 percent                                     |
| 2                           | 22.0                                                     | 29.3                                             |
| 3                           | 14.7                                                     | 18.6                                             |
| 4                           | 12.0                                                     | 12.4                                             |
| 5                           | 11.3                                                     | 12.4                                             |
| 6                           | 8.6                                                      | 2.6                                              |
| 7                           | 7.3                                                      | 2.6                                              |
| 8                           | 4.0                                                      | 2.6                                              |
| 9                           | 2.6                                                      | 1.8                                              |
| 10                          | 1.0                                                      | 0.9                                              |
| 11                          | 0.7                                                      | 0.0                                              |
| 12                          | 0.7                                                      | 0.0                                              |
| 13                          | 0.3                                                      | 0.0                                              |
| 14                          | 0.3                                                      | 0.0                                              |
| 15                          | 0.3                                                      | 0.0                                              |
| 16                          | 0.3                                                      | 0.0                                              |

A wasp of the genus Eurytoma (Eurytomidae) parasitized 20 percent of the nymphs examined in 67 galls of P. celtidis-inteneris. Most of the galls were monothalamous; 12 percent contained two cells and one gall was found which had three.

Psyllaephagus pachypsyllae and a species of Eurytoma were also reared from some petiole galls, but not enough galls could be collected to warrant a calculation of the percentage of parasitism. A third species of wasp has been reared but it has not yet been identified.

No hyperparasites were found in any of the galls; however, not enough parasites were reared to justify a statement that

hyperparasites are rare or absent.

### Insecticide Spray Tests

All of the trees treated in these tests were from five to fifteen feet high and were beginning to leaf out at the time of application. Adults of P. celtidis-vesicula were feeding and laying eggs on the young leaves, the first of which were spreading and losing their pubescence. On scattered leaves, nymphs had hatched and were feeding on the upper surfaces.

The second tree sprayed with "Black Leaf 40" and summer oil was more advanced than the others. Most of the leaves had spread and some blister galls had already formed. This accounts for the lower percentage of reduction in the number of galls by spraying.

Table 2 shows the results of the tests and the figures used in the calculations. The unexpectedly close results seem to indicate that the tests were not thorough enough to show which of the three insecticides was the most effective. Laboratory tests or more extensive and carefully controlled field tests might reveal that one of the chemicals is more effective than the others, or that different concentrations should be used. However, the tests do indicate that even a single spray application will go far toward reducing the number of galls and improving the appearance of the hackberry tree.



Table 2. Results of spray tests.

|                                  | Total number<br>of galls | : Total number<br>: of leaves | : Average number<br>: galls per leaf | : Reduction in<br>: number of galls | : Per cent<br>: reduction |
|----------------------------------|--------------------------|-------------------------------|--------------------------------------|-------------------------------------|---------------------------|
| <u>EPN-300</u>                   |                          |                               |                                      |                                     |                           |
| 1. Sprayed branch                | 104                      | 143                           | 0.73                                 |                                     |                           |
| Unsprayed branch                 | 605                      | 162                           | 3.74                                 | 3.01                                | 80.5                      |
| 2. Sprayed branch                | 240                      | 223                           | 1.09                                 |                                     |                           |
| Unsprayed branch                 | 1277                     | 201                           | 6.35                                 | 5.26                                | 82.8                      |
| Black Leaf 40 plus<br>summer oil |                          |                               |                                      |                                     |                           |
| 1. Sprayed branch                | 408                      | 230                           | 1.75                                 |                                     |                           |
| Unsprayed branch                 | 2896                     | 271                           | 10.7                                 | 8.95                                | 83.5                      |
| 2. Sprayed branch                | 310                      | 339                           | 0.92                                 |                                     |                           |
| Unsprayed branch                 | 648                      | 299                           | 2.17                                 | 1.25                                | 57.7                      |
| Gartox                           |                          |                               |                                      |                                     |                           |
| 1. Sprayed branch                | 374                      | 269                           | 0.89                                 |                                     |                           |
| Unsprayed branch                 | 807                      | 211                           | 3.83                                 | 2.94                                | 76.7                      |
| 2. Sprayed branch                | 385                      | 370                           | 1.50                                 |                                     |                           |
| Unsprayed branch                 | 2098                     | 287                           | 7.32                                 | 5.82                                | 79.3                      |

## DISCUSSION OF RESULTS

Although the tests were not sufficient to show any advantage of one chemical over another, their results, together with the details of the life-histories of the psyllids, show that the success of a chemical control will be influenced more by improper timing of the application than by the choice of insecticide.

Proper timing is complicated by two variables: the time at which the hackberries produce their first leaves, and the time at which the psyllids begin their activities on the buds of the trees. The first factor would impair the success of large-scale spraying operations because, in a large number of hackberry trees, there would be a variation of about a month in the time at which the first leaves appear. Therefore, some would be attacked by psyllids later than others and it would then be necessary to spray different trees at different dates in order to have each tree covered when the psyllids are most abundant. The second disturbing factor is the emergence of the psyllids from hibernation in two groups, the species making woody galls arriving fully a month later than those which make galls on the leaves. Because of this, two sets of spray applications, each timed in different ways, would be required.

The first spray for the psyllids making leaf galls should be applied when the first leaves have spread; another should be put on the trees about two weeks later. After these sprays, the trees must be watched for the first adults of P. celtidis-gemma and P. celtidis-inteneris. When they have emerged from

their galls and have begun to lay eggs, the third application should be made; in case of a heavy infestation by these species a fourth spray may be necessary two weeks later.

This series of four sprays would probably be uneconomical and unnecessary for extensive hackberry plantings. If control measures are aimed at only one of the two groups of psyllids in a given community, two sprays would probably greatly improve the appearance of the trees. In Manhattan, the first application would do the most good because the most important psyllid is P. celtidis-vesicula, which is most abundant when the first leaves have spread and begun to lose their downiness.

Future work on the parasites of the hackberry psyllids will probably show that they are at least as important in the control of P. celtidis-vesicula and P. celtidis-marina as they are of the other psyllids studied, and may show that a spray applied at the wrong time would kill the wasps but not the psyllid nymphs.

## SUMMARY

Five species of *Pachypsylla* were found in Manhattan, Kansas: *P. venusta* (Osten-Sacken), the petiole gall psyllid; *P. celtidis-mamma* (Fletcher), the nipple gall psyllid; *P. celtidis-vesicula* Crawford, the blister gall psyllid; *P. celtidis-germa*, the bud gall psyllid; and *P. celtidis-inteneris*, Mally, the twig gall psyllid. Examinations of thirty-five hackberry trees showed that the commonest species was *P. celtidis-vesicula* and the least common was *P. venusta*. *P. celtidis-inteneris*, which had hitherto never been recorded in Kansas, was as common as *P. celtidis-germa*. All species were irregularly distributed from tree to tree, some species being extremely abundant on some trees but rare on others.

In a study of the life-histories, it was found that the first psyllids to be seen in the spring were the leaf gall makers, *P. celtidis-vesicula* and *P. celtidis-mamma*, which always attacked the opening buds and young leaves, but rarely were seen on the leaves after they were fully spread. The woody gall makers, *P. celtidis-germa* and *P. celtidis-inteneris*, did not emerge from their galls until a month after the buds had opened.

Evidence from specimen labels and gall dissections indicated that adults of *P. venusta* emerged in the fall. However, this could not be proved directly, because no living nymphs were found in the fall or spring.

Attempts to find where the other species of psyllids hibernated failed to yield any results, possibly indicating that they were too widely dispersed or too well hidden to be found by simple observations alone.

The following species of parasitic wasps were reared from psyllid galls collected during the winter and confined in vials at room temperature:

From P. celtidis-gemma:

Torymus scalaris (Huber)

Psyllaephagus pachypsylae (How.)

From P. venusta:

Psyllaephagus pachypsylae

Eurytoma sp.

From P. celtidis-inteneris:

Eurytoma sp.

Gall dissections showed that 18.6 percent of the nymphs of P. celtidis-gemma were parasitized and 20 percent of the nymphs of P. celtidis-inteneris were infested. The dissections also showed that bud galls may contain from one to ten cells; 29.3 percent of the galls contained two cells, and other sizes were less prevalent. Twelve per cent of the twig galls contained two cells; the rest were monothalamous except for one instance in which the gall was three-celled.

Preliminary insecticide spray tests were made with "Gamtox", "EPN-300", and "Black Leaf 40" combined with summer oil. With a three-gallon compressed air hand sprayer, a single application of each insecticide was made on selected branches

of two different trees at the time the first leaves were unfolding. By comparing the number of blister galls per leaf on the sprayed and unsprayed branches it was found that each of the three insecticides reduced the number of galls from 76 per cent to 82 per cent. It was concluded that, since all of the toxicants showed good results, the success of a chemical control for hackberry psyllids was influenced more by proper timing of the applications than by the choice of insecticide.

While four applications would give the best control of all species of psyllid, the first alone would be the most valuable in Manhattan, as far as improvement of the appearance of the hackberry trees is concerned, since this would be the most effective against P. celtidis-vesicula, which is responsible for most of the disfigurement of the hackberry trees in this area.



EXPLANATION OF PLATE I

Petiole galls of Pachypsylla venusta.  
(Courtesy Dr. R. C. Smith.)

PLATE I



EXPLANATION OF PLATE II

Eggs of Pachynsylvia celtidis-vesicula  
on lower side of hackberry leaf.  
(Original photograph)

PLATE II



EXPLANATION OF PLATE III

Nymphs of Pachypsylla celtidis-vesicula  
on upper side of hackberry leaf.  
(Original photograph)

## PLATE III





EXPLANATION OF PLATE IV

Nipple galls of Pachypsylla celtidis-mamma.  
(Courtesy Dr. R. C. Smith)

PLATE IV



EXPLANATION OF PLATE V

Twigs heavily infested with bud galls  
of Pachyosylla celtidis-gemma.  
(Courtesy Dr. R. C. Smith)

PLATE V



EXPLANATION OF PLATE VI

Twig heavily infested with galls of Pachypsylla  
celtidis-inteneris. Individual galls are indicated  
by horizontal lines.  
(Original photograph)



## ACKNOWLEDGEMENT

The author wishes to express his gratitude to Dr. R. C. Smith for suggesting this problem, and for his patient guidance and helpful suggestions during the course of the work; and to the members of the Department of Entomology for their constant encouragement.

Acknowledgment is also due to Mr. C. F. W. Muesebeck, Dr. B. D. Burks, and Miss Louise M. Russell of the U. S. Bureau of Entomology and Plant Quarantine for their identification of the psyllids and parasitic wasps.



## LITERATURE CITED

- Caldwell, John S.  
The jumping plant lice of Ohio. Ohio Biol. Surv. 6(5):254-259. 1938.
- Caldwell, John S.  
Notes on Mexican and Central American Psyllidae (Homoptera). Ohio Jour. Sci. 44(2):57-64. 1944.
- Crawford, David L.  
A monograph of the jumping plant lice or Psyllidae of the New World. U. S. Natl. Mus. Bul. 85:108-113. 1914.
- Felt, Ephraim Porter and S. W. Bromley.  
Shade tree insects in 1929. Jour. Econ. Ent. 23(1):137-142. 1930.
- Huber, L. L.  
A taxonomic and ecological review of the North American Chalcid flies of the genus Callinome. U. S. Natl. Mus. Proc. 70(2663):114. 1927.
- Jensen, D. D.  
A new Euphalerus and notes on other species of Psyllidae from Idaho (Homoptera:Psyllidae). Ent. Soc. Amer. Ann. 39(2):242-246. 1946.
- Klyver, Fred D.  
Biological notes and new records of North American Chermidae. (Homoptera). Ent. News. 43(2):33-40. 1932.
- Knowlton, George F.  
Notes on injurious Utah insects. Utah Acad. Sci. Arts and Letters Proc. 10:159-162. 1933.
- Kotinsky, Jacob.  
Insects injurious to deciduous shade trees and their control. U. S. Dept. Agr. Farmers' Bul. 1169:91. 1921.
- Mally, Charles W.  
Hackberry psyllids found at Ames, Iowa. Iowa Acad. Sci. Proc. 1 pt. 4:131-138. 1894.
- Packard, Alpheus S.  
Insects injurious to forest and shade trees. U. S. Dept. Agr. Ent. Comm., fifth rept. 957p. 1890.

- Slingerland, M. V.  
Galls that infest the mulberry. Rural New Yorker. 54(2361):  
297. 1895.
- Stough, H. B.  
The hackberry psylla, Pachypsylla celtidis-mamma (Fletcher).  
Kans. Univ. Sci. Bul. 5(9):121-165, pl. xxvi-xxxv. 1910.
- Tuthill, Leonard D.  
The psyllids of America north of Mexico (Psyllidae:Homop-  
tera). Iowa St. Col. Jour. Sci. 17(4):443-660. 1943.
- U. S. Department of Agriculture.  
Trees for roadside planting. U. S. Dept. Agr. Farmers' Bul.  
1482:18. 1926.
- U. S. Forest Experiment Station, Lake States, St. Paul, Minn.  
Possibilities of shelterbelt planting in the Plains region.  
U. S. Forest Service, Washington, U. S. Govt. Print. Off.  
201.p. 1935.
- Walton, Cyprian James.  
The biology of Pachypsylla celtidis-gemma Riley and the  
relationship of the parasite to the bud of Celtis occi-  
dentalis. Fordham Univ. Doctor's Dissertation. 100 p. 1944.
- Waterston, James.  
On the chalcidoid parasites of psyllids (Hemiptera:Homop-  
tera). Bul. Ent. Res. 13(1):41-58. 1925.
- Weiss, Harry B.  
Notes on the life-history of Pachypsylla celtidis-gemma  
Riley. Canad. Ent. 53(1):19-21. 1921.
- Wells, Bertram W.  
The comparative morphology of the zooecidia of Celtis  
occidentalis. Ohio Jour. Sci. 16(7):249-290. 1916.

THE BIOLOGY AND CONTROL OF THE HACKBERRY PSYLLIDS  
AT HAMILTON, KANSAS

by

RICHARD EMMERY TAYLOR

B. S., Michigan State College, 1950

---

ABSTRACT OF THESIS

submitted in partial fulfillment of the

requirements for the degree of

MASTER OF SCIENCE

Department of Entomology

KANSAS STATE COLLEGE  
OF AGRICULTURE AND APPLIED SCIENCE

1952

Throughout their range, hackberry trees (Celtis) are subject to the attacks of gall making psyllids of the genus Pachypsylla (Psyllidae: Homoptera). In severe infestations by certain species, especially P. celtidis-vesicula, the blister-gall psyllid, and P. celtidis-gemma, the nipple gall psyllid, the trees are often made so unsightly as to lower their value as shade trees in cities and around private homes.

It is the purpose of this investigation to survey the life-histories of all species of Pachypsylla in Manhattan, Kansas, and to determine the feasibility of the use of insecticidal sprays for the control of these insects.

Periodic examinations were made of thirty-five hackberry trees in the vicinity of Kansas State College, to determine what species of gall making psyllids were present, the relative abundance of each species, and the details of their life-histories.

Several species of parasitic wasps were reared from the woody galls of P. celtidis-gemma, the bud gall psyllid, and P. celtidis-inteneris, the twig gall psyllid, by pruning gall-bearing twigs from trees during January and February of 1961 and confining the twigs in vials at room temperature. By dissecting galls with a needle and counting the number of parasitized psyllid nymphs the percentage of parasitism was calculated.

In insecticidal spray tests designed specifically to control P. celtidis-vesicula, the commonest gall psyllid in Manhattan, six trees were sprayed with "Dantox", "EPA-300", and

"Black Leaf 40" combined with "Superia" summer oil. Each insecticide was applied to a single branch on each of two trees when the trees began to leaf out; blister gall psyllids were feeding and laying eggs on the young leaves at the time of application. Two months after the sprays were applied, the percentage of reduction in the number of blister galls was calculated by finding the average number of galls per leaf on the sprayed branch and comparing it with the average for the rest of the tree.

Five species of gall psyllids were found in Manhattan: P. venusta, the petiole gall psyllid; P. celtidis-manna, the nipple gall psyllid; P. celtidis-vesicula, the blister gall psyllid; P. celtidis-cornu, the bud gall psyllid; and P. celtidis-inteneris, the twig gall psyllid, which had never before been recorded in Kansas. P. venusta was quite uncommon; no adults were collected and few galls were found. P. celtidis-vesicula was very prevalent and was responsible for most of the disfigurement of the trees. The other species were slightly less common. All species showed marked localization in the intensity of their infestations.

In the spring the psyllids which make leaf galls, P. celtidis-vesicula and P. celtidis-manna, appeared on the hackberry trees when the first buds were opening and the young leaves were beginning to expand. They could be found thereafter as long as there were buds beginning to open. The woody gall psyllids, P. celtidis-cornu and P. celtidis-inteneris, which hibernated as nymphs in their galls, did not emerge until about a month after the first leaf gall psyllids appeared.

The feeding, copulating and egg-laying activities and habits of the nymphs of each species were observed and found to agree closely with results recorded in the literature.

Two species of wasps were reared from bad galls: Torymus spulalis and Psyllaephagus nachhypsyllae. These wasps infested 10.5 per cent of the psyllid nymphs. A wasp of the genus Eurytoma infested 20 per cent of the nymphs of P. solitidis-inteneris. P. venusta was also parasitized by Psyllaephagus nachhypsyllae and a species of Eurytoma. Gall dissections also showed that bad galls may contain from one to ten cells, with 92.5 per cent containing two cells. Almost all of the twig galls were monothalamous.

Results of the insecticidal spray tests showed that all three of the insecticides were effective in reducing the number of blister galls. "EPA-300" reduced them 80.5 per cent on one tree and 62.3 per cent on the other; "Dantox", 75.7 per cent and 79.3 per cent; and "Black Leaf 40" with oil, 35.8 per cent and 57.7 per cent. The last figure was low because some blister galls had already formed at the time of spray application.

It was concluded that a single insecticidal spray applied at the time the trees begin to leaf out will go far toward reducing the numbers of blister galls and improving the appearance of the tree. To control all species of gall psyllids, more applications are necessary at intervals over a period of two to three months.